Climate of the Past Discussions

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Comment on cp-2022-38

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Referee comment on "Is it possible to estimate aerosol optical depth from historic colour paintings?" by Christian von Savigny et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2022-38-RC1, 2022

The manuscript is concerned with estimating the uncertainties related to deriving the Aerosol Optical Depth (AOD) from the coloring of the sky in paintings made at the time of large volcanic eruptions. As such, the manuscript provides a critical comment to existing publications that are aiming at deriving such values. Using an atmospheric radiative transfer model, the manuscript presents a number of sensitivity studies by varying a number of parameters that may lead to uncertainties in the color-based AOD estimates. The manuscript is well written and easy to follow and the various uncertainties brought to the table appear relevant.

I do not have comments on the radiative transfer model for which I am not an expert, but I have two suggestions for the authors to consider:

My first point concerns the 'true' error related to AOD estimates from paintings. For historical volcanic eruptions, there are ice-core based estimates of the sulfate deposition in both Greenland and Antarctica that provide an independent estimate of the stratospheric sulfate aerosol loading, which in turn can be translated into an stratospheric AOD (Gao et al., 2007;Gao et al., 2008;Sigl et al., 2015). Can those estimates be applied to give an independent estimate of the accuracy of the paintings derived AOD? Of course, the ice-core estimates can be questioned themselves, but a reasonable agreement between the two independent approaches would nevertheless suggest that both methods are providing AOD estimates that are in the right order of magnitude, at least. Likewise, a large disagreement between the two methods would suggest that at least one of them has very large uncertainties. Maybe this comparison has already been done in another study? It seems like a quite obvious comparison to make?

My second point concerns an overall error estimate for the historic color painting method for estimating the stratospheric aerosol optical thickness based on the uncertainties introduced in the present manuscript. In the manuscript, we are provided with numerous figures showing the AOD sensitivity to factors such as particle size distribution,

wavelength, solar zenith angle, albedo, azimuth angle, etc. All of those dependencies certainly leave the impression 'that the uncertainties of the estimated aerosol optical depths are so large that the values have to be considered highly questionable', as mentioned in the abstract. However, how large are the uncertainties 'typically' in a real-case scenario? If we add up all of the uncertainties using a realistic range of values for the parameters discussed in the study, do we then end up with 5% or 50% uncertainty on the final result? If the total uncertainty is in the range below say 50%, the method may still be applicable, eg if there are several paintings of the (sky of the) same eruption that may provide independent evidence. If the final uncertainty estimate is large however, say above 50%, the entire approach of using paintings for estimating the AOD becomes questionable. Therefore, some kind of summary providing a combined uncertainty from all of the discussed parameters would be quite helpful. Also, an estimate of the relative uncertainty contribution from each investigated parameter would be helpful again using a realistic range of parameters. If possible, some uncertainty estimates/ranges could be provided in a table? This may provide some useful guidance for future studies of what knowledge is needed to make constrained AOD estimates from paintings. Maybe, in some cases, there is independent evidence of say the position of the Sun or the time of the day when the picture was painted? Likewise, we may become wiser in the future about what to expect from the particle size distribution related to large volcanic eruptions. Thus - wearing an optimistic hat - it could be that some of the uncertainty ranges discussed in the manuscript could be significantly reduced or even eliminated for specific paintings/eruptions?

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